CHAPTER II - RECONNAISSANCE AND FIXES

1. GENERAL

The Joint Typhoon Warning Center depends on reconnaissance to provide necessary, accurate, and timely meteorological information in support of each warning. JTWC relies primarily on three sources of reconnaissance: aircraft, satellite, and radar. Optimum utilization of all available reconnaissance resources is obtained through use of the Selective Reconnaissance Program (SRP), whereby various factors are considered in selecting a specific reconnaissance platform for each warning. These factors include: cyclone location and intensity, reconnaissance platform capabilities and limitations, and the cyclone's threat to life/property afloat and ashore. A summary of reconnaissance fixes received during 1980 is included in Section 6.

2. RECONNAISSANCE AVAILABILITY

a. Aircraft:

Aircraft weather reconnaissance is performed in the JTWC area of responsibility by the 54th Weather Reconnaissance Squadron (54 WRS). The squadron, presently equipped with six WC-130 aircraft, is located at Andersen Air Force Base, Guam. From July through October, augmentation by the 53rd WRS at Keesler Air Force Base, Mississippi brings the total number of available aircraft to nine. The JTWC reconnaissance requirements are provided daily throughout the year to the Tropical Cyclone Aircraft Reconnaissance Coordinator (TCARC). These requirements include area(s) to be investigated, tropical cyclone(s) to be fixed, fix times, and forecast positions of fixes. The following priorities are utilized in acquiring meteorological data from aircraft, satellite, and land-based radar in accordance with CINCPACINST 3140.1N:

"(1) Investigative flights and vortex or center fixes for each scheduled warning in the Pacific area of responsibility. One aircraft fix per day of each cyclone of tropical storm or typhoon intensity is desirable.

(2) Supplementary fixes.

(3) Synoptic data acquisition."

As in previous years, aircraft reconnaissance provided direct measurements of height, temperature, flight-level winds, sea level pressure, estimated surface winds (when observable), and numerous additional parameters. The meteorological data are gathered by the Aerial Reconnaissance Weather Officers (ARWO) and dropsonde operators of Detachment 4, Hq AWS who fly with the 54th. These data provide the Typhoon Duty Officer (TDO) indications of changing cyclone characteristics, radius of cyclone associated winds, and present cyclone position and intensity. Another important aspect of these data is their availability for research in tropical cyclone analysis and forecasting.

b. Satellite

Satellite fixes from USAF ground sites and USN ships provide day and night coverage in the JTWC area of responsibility. Interpretation of this satellite imagery provides cyclone positions and estimates of storm intensities through the Dvorak technique (for daytime passes).

Detachment 1, 1st Weather Wing, which receives and processes polar orbiting satellite data, is the primary fix site for the western North Pacific. Satellite fix positions received at JTWC from the Air Force Global Weather Central (AFGWC), Offutt Air Force Base, Nebraska and the Naval Oceanography Command Detachment at Deigo Garcia were the major sources of satellite data for the Indian Ocean. GOES fixes were also provided by the National Environmental Satellite Service, Honolulu, Hawaii for tropical cyclones near the dateline.

c. Radar

Land radar provides positioning data on well developed cyclones when in proximity (usually within 175 nm (324 km) of the radar site) of the Republic of the Philippines, Taiwan, Hong Kong, Japan, the Republic of Korea, Kwajalein, and Guam.

d. Synoptic

In 1980, the JTWC also determined tropical cyclone positions based on the analysis of the surface/gradient level synoptic data. These positions were helpful in situations where the vertical structure of the tropical cyclone was weak or accurate surface positions from aircraft were not available due to flight restrictions.

3. AIRCRAFT RECONNAISSANCE SUMMARY

During the 1980 tropical season, the JTWC levied 213 six-hourly vortex fixes and 65 investigative missions. In addition to the levied vortex fixes, 133 supplemental fixes were also obtained. The number of levied investigative missions has increased steadily over the past five years in response to JTWC's increased efforts to detect initial tropical cyclone development. The average vector error for all aircraft fixes received at the JTWC during 1980 was 17 nm (31 km).

Aircraft reconnaissance effectiveness is summarized in Table 2-1 using the criteria as set forth in CINCPACINST 3140.1N.

TABLE 2-1. AIRCRAFT RECONNAISSANCE EFFECTIVENESS

EFFECTIVENESS		NUMBER OF LEVIED FIXES	PERCENT
COMPLETED ON TIME		190	89.2
EARLY		5	2.3
LATE		14	6.6
MISSED		4	1.9
	TOTAL	213	100.0

LEVIED VS. MISSED FIXES

	LEVIED	MISSED	PERCENT
AVERAGE 1965-1970	507	10	2.0
1971	802	61	7.6
1972	624	126	20.2
1973	227	13	5.7
1974	358	30	8.4
1975	217	7	3.2
1976	317	11	3.5
1977	203	3	1.5
1978	290	2	0.7
1979	289	14	4.8
1980	213	4	1.9

4. SATELLITE RECONNAISSANCE SUMMARY

The Air Force provides satellite reconnaissance support to JTWC using imagery data from DMSP and NOAA polar-orbiting spacecraft. The NOAA imagery processing capability was new for DMSP tactical site operations during 1980. Western North Pacific DMSP tactical sites received this additional capability in February 1980 in sufficient time for the Northern Hemisphere tropical cyclone season.

The DMSP cyclone surveillance network consists of both tactical and centralized facilities. Tactical DMSP sites are located at Nimitz Hill, Guam; Clark AB, Philippines; Kadena AB, Japan; Osan AB, Korea; and Hickam AFB, Hawaii. These sites provide a combined coverage that covers the JTWC area of responsibility in the western North Pacific from near the dateline westward to the Malay Peninsula. An important addition in 1980 was the Navy tactical site at Diego Garcia. Unlike the DMSP sites, Diego Garcia can process only NOAA polar-orbiting meteorological spacecraft. However, the unique coverage of this site, located in the central South Indian Ocean, greatly expanded the satellite reconnaissance network's coverage of this vital area. Prior to 1980, the JTWC had to depend entirely on the Air Force Global Weather Central (AFGWC) for all Indian Ocean cyclone reconnaissance.

AFGWC is the centralized member of the satellite cyclone surveillance network. Located at Offutt AFB, Nebraska, AFGWC has the capability to process the daily worldwide coverage of two polar-orbiting spacecraft, whether DMSP or NOAA. This enables AFGWC to provide coverage four times daily over the entire JTWC area of responsibility. Imagery processed at AFGWC is recorded on-board the spacecraft as it passes over the earth. Later, these data are downlinked to AFGWC via a network of command/readout sites and communications satellites. This enables AFGWC to obtain the coverage necessary to fix all cyclones of interest to JTWC. AFGWC has the primary responsibility to provide cyclone surveillance over the entire Indian Ocean, a small portion of the western North Pacific near the dateline, as well as the South Pacific from the dateline westward to the Indian Ocean. Additionally, AFGWC can be tasked to provide storm positions in the western North Pacific as backup to the tactical site coverage routinely available in this region.

The thread that ties the network together is Det 1, 1WW colocated with JTWC atop Nimitz Hill, Guam. Based on available satellite coverage, Det 1 coordinates satellite reconnaissance requirements with JTWC and tasks the individual network sites for the necessary storm fixes. The tasking concept is to position every cyclone or disturbance once from each satellite pass that covers the cyclone. Further, when a satellite position is required as the basis for a warning, called a levied fix, a dual-site tasking concept is applied. Under this concept, two sites are tasked to fix the cyclone off the same satellite pass. This provides the necessary redundancy to virtually guarantee JTWC a successful satellite fix of the cyclone. Using this dual-site concept, the satellite reconnaissance network was able to meet percent of JTWC's levied satellite fix requirements. This year, dual-site tasking was extended to most of the Indian Ocean with the addition of the Navy site at Diego Garcia to the tactical site network. Previously, dual-site tasking was available only in the western North Pacific.

The network provides JTWC with several products and services. The main service is one of surveillance. With the exception of Osan, each site reviews its daily coverage for any indications of development. If an area shows indications of development, JTWC is notified. Once JTWC issues either an alert or warning, the network is tasked to provide three products: cyclone positions, cyclone intensity estimates, and 24-hour cyclone intensity forecasts. Satellite cyclone positions are assigned position code numbers (PCN) depending on the availability of geography for precise gridding and the degree of organization of the cyclone's circulation center (Table 2-2). During 1980, the network provided JTWC with 1327 satellite fixes of tropical cyclones. A comparison of those fixes made on numbered tropical cyclones with their corresponding JTWC best

TABLE 2-2. POSITION CODE NUMBERS

PCN	METHOD OF CENTER DETERMINATION/GRIDDING
1	EYE/GEOGRAPHY
2	EYE/EPHEMERIS
3	WELL DEFINED CC/GEOGRAPHY
4	WELL DEFINED CC/EPHEMERIS
5	POORLY DEFINED CC/GEOGRAPHY
6	POORLY DEFINED CC/EPHEMERIS

CC=Circulation Center

TABLE 2-3. MEAN DEVIATIONS (NM) OF DMSP, NOAA6, AND TIROS N DERIVED TROPICAL CYCLONE POSITIONS FROM JTWC BEST TRACK POSITIONS. NUMBER OF CASES IN PARENTHESIS.

PCN	WESTPAC 1974-1979 AVERAGE (ALL SITES)	WESTPAC 1980 (ALL SITES)	INDIAN OCEAN 1980 (ALL SITES)
1	13.5 (193)	12.2 (76)	-
2	18.4 (67)	16.2 (13)	-
3	20.6 (282)	20.4 (153)	-
4	25.0 (96)	12.9 (11)	-
5	37.3 (407)	39.2 (318)	35.7 (8)
6	46.4 (197)	33.3 (81)	44.6 (12)
1&2	14.8 (260)	12.8 (89)	-
3&4	21.4 (378)	19.9 (164)	-
5&6	40.3 (604)	38.0 (399)	41.0 (20)

track positions is shown in Table 2-3. Estimates of the cyclone's current intensity and a 24-hour intensity forecast are made once each day by applying the Dvorak technique (NOAA Technical Memorandum NESS 45 as revised) to daylight visual data. Figure 2-1 compares these current intensity and forecast intensities with the observed cyclone intensities for the 1980 storm season. Satellite-derived cyclone positions, intensity estimates, and intensity forecasts constitute the satellite portion of the JTWC forecast data base.

The availability of polar-orbiting meteorological satellites declined during the year as spacecraft failures plagued the network. Two scheduled launches, one DMSP and one NOAA, encountered launch vehicle problems that resulted in the failure of the platforms to achieve orbit. Therefore, no new spacecraft became available this year. At the first of the year, three spacecraft were fully operational: DMSP FTV 13536 (F-2) in a mid-morning orbit, NOAA-6 in a sunrise orbit, and TIROS-N in a mid-afternoon orbit. Further, the DMSP spacecraft FTV 15539 (F-4) was operational for late morning passes only. Subsequent failures rapidly decimated these ranks. TIROS-N first failed in late January, was recovered in February, but failed for good in early November. However, TIROS-N was operational for most of the Northern Hemisphere tropical cyclone season. F-2 failed in February and F-4 failed in August. F-3 (FTV 14537) failed initially in December 1979 but was partially recovered in April 1980. While F-3's coverage was limited to the center 50 percent of the visual imagery only, its ascending (daylight) coverage was fully incorporated into surveillance network operations, particularly to support the JTWC

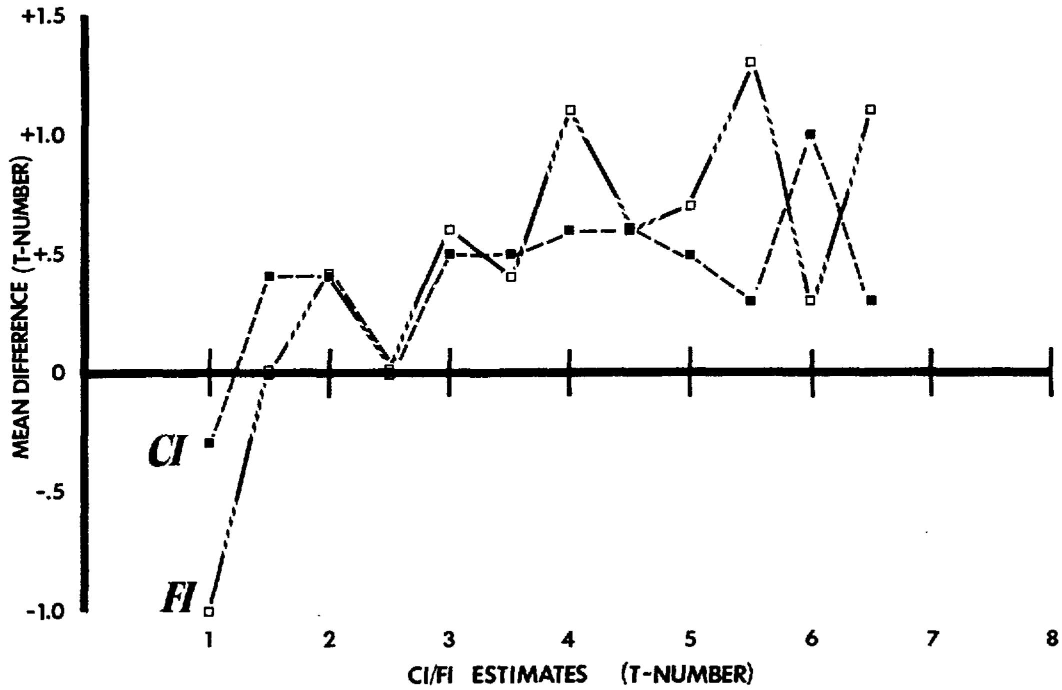


FIGURE 2-1. DVORAK Current Intensity (CI) errors and Forecast Intensity (FI) errors for 1980 (116 cases). Comparisons are made against the best track intensity values, in which the CI's were used along with aircraft reconnaissance data to determine the best track intensities. (Shewchuk and Weir, 1980)

0000Z warning. Therefore, by the end of the season, the only fully operational polar-orbiting spacecraft was NOAA-6.

Besides fixes from the network, JTWC also received satellite-derived cyclone positions from several secondary sources during 1980. These included: the Naval Oceanography Command Detachment (NOCD) Cubi Point, Philippines; U. S. Navy ships equipped for direct readout; the National Environmental Satellite Service (NESS) using NOAA and GOES data; and the Naval Polar Oceanography Center, Suitland, Maryland using stored-DMSP and NOAA data. Fixes from these secondary sources are not included in the network statistics.

5. RADAR RECONNAISSANCE SUMMARY

Ten of the 28 significant tropical cyclones occurring over the western North Pacific during 1980 passed within range of land based radars with sufficient cloud pattern organization to be fixed. The hourly and oftentimes, half-hourly land radar fixes that were obtained and transmitted to JTWC totaled 413.

The WMO radar code defines three categories of accuracy: good (within 10 km (5.4 nm)), fair within 10-30 km (5.4-16.2 nm)), and poor (within 30-50 km (16.2-27 nm)). This year, 413 radar fixes were coded in this manner; 147 were good, 153 fair, and 113 poor. Compared to the JTWC best track, the mean vector deviation for land radar sites was 15 nm (28 km). Excellent support through timely and accurate radar fix positioning allowed JTWC to track and forecast tropical cyclone movement through even the most difficult and erratic tracks.

The 54 WRS made 2 radar center fixes from their WC-130 aircraft when actual tropical cyclone penetration was restricted. No radar fixes were received on Indian Ocean tropical cyclones.

6. TROPICAL CYCLONE FIX DATA

A total of 2134 fixes on 28 northwest Pacific tropical cyclones and 35 fixes on 2 northern Indian Ocean tropical cyclones were received at JTWC. Table 2-4, Fix Platform Summary, delineates the number of fixes per platform for each individual tropical cyclone. Season totals and percentages are also indicated.

Annex A includes individual fix data for each tropical cyclone. Fix data are divided into four categories: Satellite, Aircraft, Radar, and Synoptic. Those fixes labelled with an asterisk (*) were determined to be unrepresentative of the surface center and were not used in determining the best tracks. Within each category, the first three columns are as follows:

FIX NO. - Sequential fix number

TIME (Z) - GMT time in day, hours and minutes

FIX POSITION - Latitude and longitude to the nearest tenth of a degree

Depending upon the category, the remainder of the format varies as follows:

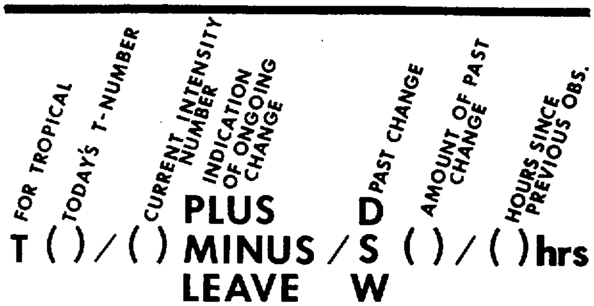
a. Satellite

(1) ACCRY - Position Code Number (PCN) is used to indicate the accuracy of the fix position. A "1" indicates relatively high accuracy and a "6" relatively low accuracy.

TABLE 2-5. MAXIMUM SUSTAINED WIND SPEED (KT) AS A FUNCTION OF DVORAK T NUMBER AND MINIMUM SEA LEVEL PRESSURE (MSLP)

TROPICAL CYCLONE INTENSITY	WIND SPEED	MSLP (NW PACIFIC)
T 1.0	25	—
T 1.5	25	—
T 2.0	30	1003
T 2.5	35	999
T 3.0	45	994
T 3.5	55	988
T 4.0	65	981
T 4.5	77	973
T 5.0	90	964
T 5.5	102	954
T 6.0	115	942
T 6.5	127	929
T 7.0	140	915
T 7.5	155	900
T 8.0	170	884

(2) DVORAK CODE - Intensity evaluation and trend utilizing visual satellite data. (For specifics, refer to NOAA TM; NESS-45)(Table 2-5).



EXAMPLE: T5/6 MINUS/W1.5/24hrs.

(3) SAT - Specific satellite used for fix position (DMSP 37 or 39, TIROS-N, NOAA6, Other, or Geostationary Operational Environmental Satellite (GOES, 135W)).

(4) COMMENTS - For explanation of abbreviations, see Appendix.

(5) SITE - ICAO call sign of the specific satellite tracking station.

b. Aircraft

(1) FLT LVL - The constant pressure surface level, in mb, maintained during the penetration. Seven hundred mb is the normal level flown in developed cyclones due to turbulence factors. Low-level missions are flown at 1500 ft.

(2) 700 MB HGT - Minimum height of the 700 mb pressure surface within the vortex recorded in meters.

TABLE 2-4 FIX SUMMARY FOR 1980

FIX SUMMARY

	AIRCRAFT	DMSP	NOAA6	TIROS-N	GOES3	OTHER SAT	RADAR	SYNOPTIC	TOTAL
WESTERN PACIFIC									
TD 01	9	16	12	-	-	14	-	5	56
TS CARMEN	-	4	10	3	15	20	-	-	52
TY DOM	24	34	27	2	-	33	-	-	120
TY ELLEN	25	26	19	2	-	25	-	-	97
TS FORREST	19	15	14	1	-	18	7*	-	74
TS GEROGIA	2	5	9	3	-	11	-	7	37
TS HERBERT	4	15	12	-	-	27	-	5	63
TS IDA	12	20	12	5	-	13	-	-	62
TY JOE	13	13	11	2	-	21	3	2	65
TD 10	-	4	6	-	-	9	-	3	22
ST KIM	23	16	16	3	-	21	-	-	79
TY LEX	21	22	21	1	-	29	-	-	94
TY MARGE	9	5	15	3	-	24	-	-	56
TD 14	1	1	4	3	-	11	-	-	20
TY NORRIS	12	2	14	12	-	21	41	-	102
TD 16	3	1	8	3	-	7	-	-	22
TY ORCHID	13	1	12	10	-	21	51	-	108
TY RUTH	-	-	7	5	-	13	1	2	28
TY PERCY	13	3	12	13	-	17	43	-	101
TY SPERRY	10	1	16	3	-	20	10	-	60
TS THELMA	8	-	8	8	-	22	-	-	46
TY VERNON	18	4	15	2	-	30	-	-	69
ST WYNNE	51	3	26	14	-	51	195	-	340
TS ALEX	6	-	10	-	-	14	-	-	30
TY BETTY	36	3	26	4	-	51	46	-	166
TS CARY	3	-	7	7	-	17	-	-	34
TY DINAH	15	-	8	-	-	30	17	-	70
TS ED	16	-	15	-	-	27	-	3	61
TOTAL	366	214	372	109	15	617	414	27	2134
% OF TOTAL NO. OF FIXES	17.1	10.0	17.4	5.1	.7	29.0	19.4	1.3	100

* INCLUDES 2 AIRCRAFT RADAR FIXES

	NOAA6	OTHER	SYNOPTIC	TOTAL
INDIAN OCEAN				
TC 23-80	12	-	-	12
TC 27-80	11	22	2	35
TOTAL	23	22	2	47
% OF TOTAL NO. OF FIXES	48.9	46.8	4.3	100

(3) OBS MSLP - If the surface center can be visually detected (e.g., in the eye), the minimum sea level pressure is obtained by a dropsonde released above the surface vortex center. If the fix is made at the 1500-foot level, the sea level pressure is extrapolated from that level.

(4) MAX-SFC-WND - The maximum surface wind (knots) is an estimate made by the ARWO based on sea state. This observation is limited to the region of the flight path and may not be representative of the entire cyclone. Availability of data is also dependent upon the absence of undercast conditions and the presence of adequate illumination. The positions of the maximum flight level wind and the maximum observed surface wind do not necessarily coincide.

(5) MAX-FLT-LVL-WND - Wind speed (knots) at flight level is measured by the AN/APN 147 doppler radar system aboard the WC-130 aircraft. Values entered in this category represent the maximum wind measured prior to obtaining a scheduled fix. This measurement may not represent the maximum flight level wind associated with the tropical cyclone because the aircraft only samples those portions of the tropical cyclone along the flight path. In most instances, the flight path is through the weak sector of the cyclone. In areas of heavy rainfall, the doppler radar may track energy reflected from precipitation rather than from the sea surface, thus, preventing accurate wind speed measurement. In obvious cases, such erroneous wind data will not be reported. In addition, the doppler radar system on the WC-130 restricts wind measurements to drift angles less than or equal to 27 degrees if the wind is normal to the aircraft heading.

(6) ACCRY - Fix position accuracy. Both navigational (OMEGA and LORAN) and meteorological (by the ARWO) estimates are given in nautical miles.

(7) EYE SHAPE - Geometrical representation of the eye based on the aircraft radar presentation. The eye shape is reported only if the center is 50% or more surrounded by wall cloud.

(8) EYE DIAM/ORIENTATION - Diameter of the eye in nautical miles. In case of an elliptical eye, the lengths of the major and minor axes and the orientation of the major axis are respectively listed. In the case of concentric eye walls, both diameters are listed.

c. Radar

(1) RADAR - Specific type of platform utilized for fix (land radar site, aircraft, or ship).

(2) ACCRY - Accuracy of fix position (good, fair, or poor) as given in the WMO ground radar weather observation code (FM20-V).

(3) EYE SHAPE - Geometrical representation of the eye given in plain language (circular, elliptical, etc.).

(4) EYE DIAM - Diameter of eye given in kilometers.

(5) RADOB CODE - Taken directly from WMO ground weather radar observation code FM20-V. The first group specifies the vortex parameters, while the second group describes the movement of the vortex center.

(6) RADAR POSITION - Latitude and longitude of tracking station given in tenths of a degree.

(7) SITE - WMO station number of the specific tracking station.

d. Synoptic

(1) INTENSITY ESTIMATE - TDO's analysis of low-level synoptic data to determine a cyclone's maximum sustained surface wind (knots).

(2) NEAREST DATA - Accuracy of fix based on distance (nautical miles) from the fix position to the nearest synoptic report or to the average distance of reports in data sparse cases.